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**The Effects of Instructional Modes and Mental and Physical Practice  
on the Sit-to-Stand Movement**

**by**



**Shirley Marianne Attridge**

**A Thesis  
Submitted to the  
Faculty of Graduate Studies and Research  
through the Department of Kinesiology  
in Partial Fulfillment of the  
requirements for the Degree of  
Master of Human Kinetics at  
the University of Windsor**

**Windsor, Ontario, Canada**

**1989**

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### ABSTRACT

This study investigated the effects of instruction and practice techniques on the ability to change the force production of the sit-to-stand movement. Two age groups were tested in each of two experiments. The age groups were in each case 20-30 years and 65-81 years. The first experiment tested subjects under two conditions of video and verbal versus non-verbal (written) instructions over 6 practice trials. The second experiment tested subjects under conditions of 100% physical practice and 50% mental and 50% physical practice. For both experiments the design was a 3 way ANOVA with repeated measures on practice trials.

Data were collected using an A.M.T.I. force platform using the Power and Computer Automated Gait software packages. The power program was used to weigh the subjects seated on the platform, while the CAG program was used to sample the peak vertical (Z) force values during trials lasting 3s. From these values, the peak Z force above body weight, normalized for body weight, was calculated for each trial and these data were used in subsequent analyses.

From Experiment 1, it was found that, after experiencing a single teaching intervention, the reduction of peak Z force with practice was not significantly different between instructional modes. There was a significant effect of practice trials and of the interaction between age and trials. From Experiment 2, it was found that 50% physical practice and 50% mental practice was as effective as physical practice alone. In the younger age group, mental practice proved the superior practice condition but this was not true for the older adults. Although older adults improved using mental practice, they achieved lower force ratios with physical practice. These results are discussed in terms of the differences between older and younger adults with reference to adapting the principles of perceptual-motor behaviour to clinical practice.

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## CONTENTS

<b>Abstract</b>	<b>iii</b>
<b>Acknowledgements</b>	<b>iv</b>
<b>Chapter 1: Introduction</b>	<b>1</b>
<b>Chapter 2: Review of Literature</b>	<b>3</b>
Biomechanical Factors	3
Instructional Methods	9
<b>Chapter 3: Statement of Problem</b>	<b>21</b>
<b>Chapter 4: Methods</b>	<b>22</b>
Dependent Variables	22
Independent Variables	23
Design and Analysis	24
Hypotheses	25
Subject Selection	27
Equipment	28
General Procedures	29
Procedures Specific to Experiment 1	30
Procedures Specific to Experiment 2	31
<b>Chapter 5: Results</b>	<b>33</b>
<b>Chapter 6: Discussion</b>	<b>42</b>
Purpose of the Study	42
Delimitations of the Study	43
Experiment 1	46
Experiment 2	51
General Observations	55
Concluding Remarks	58
<b>References</b>	<b>60</b>
 <b>Appendix A Raw data scores for Experiment 1 and 2</b>	 <b>65</b>
<b>Appendix B Information and Consent Forms</b>	<b>68</b>

**TABLES**

1. Incidence table for Experiment 1	<b>36</b>
2. ANOVA Table for Experiment 1	<b>37</b>
3. Incidence table for Experiment 2	<b>39</b>
4. ANOVA Table for Experiment 2	<b>40</b>

**FIGURES**

1. Graph of Means under the four conditions for Experiment 1	<b>38</b>
2. Graph of Means under the four conditions of Experiment 2	<b>41</b>
3. Graph of Trials 1 and 10 showing differences in timing characteristics	<b>44</b>
4. Graph of Peak Forces for Subject awaiting Hip Surgery	<b>49</b>



## CHAPTER 1

### INTRODUCTION

As recent demographic statistics remind us, the over-65 age group is the most rapidly growing population segment in all western countries. Governments are spending increasing sums of capital on rehabilitation services, hoping to keep these people living independently longer and out of health care facilities. Rehabilitation is defined as restoring disabled people to useful function (Dorlands Pocket Medical Dictionary). In the case of physical rehabilitation, this can involve teaching changes in posture, maintaining holds in posture, and ambulation activities.

The sit-to-stand movement is an important postural change because, without this movement, a potential ambulator will not be able to maintain independent living (Burdett, Habasevich, Pisciotto & Simon, 1985). The performance of this movement may be altered by many factors. Among these are the height and design of the chair, the pathologies of the subject, and the mechanical and anthropometric relationships of the subject to the chair. However, focusing on relatively narrow areas, such as comparing chair designs or observing subjects with one sort of pathology performing the sit-to-stand act, is not something that is readily applicable to clinical practice with the elderly. Also, a preliminary investigation by Attridge (1988) revealed that there were no significant differences in the patterns of force application during the sit-to-stand movement in healthy subjects between the ages of 5 to 75 years. For the study reported here, therefore, the focus is on how teaching styles and practice schedules might be used to improve the efficiency of the movement performance, rather than on the purely descriptive as-

pects of the standing action itself. The "perfect" movement pattern for each individual will presumably be different and it is not the intent of the study to lead subjects to change their entire patterns, but to refine them for specific features of force production.

## CHAPTER 2

### REVIEW OF LITERATURE

The purpose of this review is to summarize knowledge relevant to the study of how the elderly perform and learn skilled actions. In particular, the movement task to be analysed is the sit-to-stand movement and , therefore, the biomechanics of this movement will be also be reviewed. Finally, the processes by which mental versus physical practise and the degree or type of instruction, can be best employed to increase the efficiency of the movement pattern will be reviewed.

### BIOMECHANICAL FACTORS

#### **1. Biomechanical Analysis of the Sit-to-Stand Movement.**

There are several studies in literature that have directly analyzed the sit-to-stand movement pattern. For example, Kelley, Daines & Wood in 1976, used synchronized cinematography and electromyography. This was a seminal paper and has been referred to by most investigators when designing further research. The study used 3 males and 3 females. Each of the subjects in each gender was considered to be either tall, medium or small in height. Since all the subjects were found to perform the movement using the same basic pattern, only one subject's data were used in the results presented. The starting position of the seated subject was on an adjustable box with the hip to knee joint axis in the horizontal plane and the feet placed slightly back so that there was a 70 degree angle at the

knee joint. The trunk was erect and the arms were placed so there was a 90 degree angle at the elbows and hands were placed above the thighs with the palms facing each other. The subjects were given a specific rising time of 2 seconds controlled by metronome pacing. The results revealed that during the first 0.65 s (32.5%) of the (2 s) movement the subject was still in contact with the seat preparing for the change in posture. The centre of body mass (C of M) originally started 20 cm behind the ankle joint then moved to over the ankle joint by 0.65 s, and from there the body started to extend vertically and the C of M rose. At its maximum the C of M was 8 cm in front of the ankle joint and in the upright standing position came to rest 6 cm in front of the ankle. From graphs indicating body position, joint torques, and EMG activity versus time it was proposed that the movement was initiated by a finely tuned contraction of the hip flexors which causes the trunk to fall forward. This moved the C of M downward and forward. At the lowest point there was massive recruitment of the hip and knee extensors to lift the buttocks off the seat and propel the C of M forward and upward.

A second study (Nuzik, Lamb, VanSant & Hirt, 1986) used kinematic data from cinematography to investigate the trajectories of seven body points in the sit-to-stand movement pattern. The task was for the subjects to stand up from an wooden stool. They were given the following command:

' I want you to get ready to stand up. Scoot your feet as far back as you need to stand comfortably. Rest your hands comfortably on your thighs but do not push on them when you stand up. Do not stand until you hear me say "Stand" '.

The movement time was found to range from 1.3 to 2.5 s. During the first 20% of the movement cycle there were found to be substantial individual differences in the movement. In 23 (of the 55) subjects the highest maximal displacement angle

was that of the head which suggested that these subjects led the movement with their heads. Of the other subjects, 25 of them had maximal displacement angles at the hip and trunk suggesting that the body led the movement.

Other studies have been reported that investigated the sit-to-stand movement pattern. Bajd, Karl & Turk (1982) studied the moments of force acting around the hip, knee and ankle, using a force plate and stroboscopic photography, as one healthy subject stood from a standard chair. They found that the moments of force in the hip and knee were greatest when contact was lost with the seat, and that the ankle plantar flexion moment peaked in the upright position. Seedhom & Terayama (1976) used a biomechanical model, cinematography and a force plate to test the effect of the upper extremities in aiding the movement pattern in 2 healthy subjects as they rose from a standard height seat. They found that the use of the arms greatly reduced the forces exerted by the muscles crossing the knee joints and the forces within the knee joints. Ellis, Seedhom & Amis (1979), using similar techniques and the same biomechanical model, found that forces in the knee joint of 4 healthy subjects were smaller when rising from a motorised chair than a standard chair. Nauman, Ziv & Rang (1982) investigated joint forces in healthy subjects rising from seat heights 30%, 100% and 150% of the calcaneo-tibial length. They found that increasing the seat height to 150% of the calcaneo-tibial length decreased the knee shear force by 60%.

In conclusion, the sit-to-stand movement pattern is well described in the literature and consists of a flexion and an extension phase. The flexion phase appeared to be initiated either by a very small active contraction of the hip flexors causing the body to start falling forward or by an active movement of the head leading the motion. The end of the flexion phase occurs when the C of M moves

over the ankle joints and recruitment of the large muscles of the legs drive the C of M vertically. The first two studies employed a defined postural set which may have inhibited the normal pattern while the Kelley et al (1976) study also defined the time of the movement.

The tight neuromuscular control describing the mechanics of the sit-to-stand movement is shown in all subjects. However, all subjects have the ability to change their movement patterns to cope with limiting circumstances, for example, different heights or designs of chairs and limited accessibility ( buses and cars). Given the subjects' abilities to adapt, it is possible that they could be encouraged to make changes in the movement pattern based on some measurable parameter that encourages efficiency.

## **2. Chair Design and its Effect on the Sit-to-Stand Movement.**

The three papers presented in this section investigated chair designs to determine which one was best in terms of affording subjects easiest the sit-to-stand movement. Two of the papers used two types of chair, one of a normal design and the other of a special design (for the elderly or those with disabling pathology). Also, two groups of subjects were tested, those who were young and healthy, and those who were elderly or who had pathologies (eg hip replacement, amputee). In neither of these studies was the speed or method of egress controlled. Burdett et al, (1985) also used a chair arm vs no chair arm condition. Data collection was from cinematography and a force plate. Data analysis consisted of comparing peak hip/knee/ankle extension moments and maximum joint ranges over the four conditions. In healthy subjects, the lowest moments of force were found using the 'special' chair with arm assistance. Wheeler, Woodward, Ucovich, Perry

& Walker (1985) used a second subject group consisting of elderly females. Data were collected from videotape, EMG and electrogoniometers. Data analysis considered activity of EMG (vastus lateralis and triceps brachii) as a % cycle time on/off peak, while a combination of video and goniometric data allowed maximum trunk lean, knee and elbow flexion, and hand and feet position to be considered. Results revealed that the 'special' chair was purely for sitting since egress from it was more difficult as shown by longer acting and greater integrated EMGs and greater angles needed in hips and knees for push up relative to that of the normal chair. The increased effort was seen to be the result of the chair not having enough space underneath to get the feet back far enough.

The last study in this discussion was used only for subjects who had experienced egress problems (Clark & Faletti, 1985). Three chairs were used in comparison; a hard one, an over-stuffed one, and a 'special' one. Data analysis was from videotape only and the factors considered were egress time, mean angle of hip flexion, number of posture changes and the angle of the hip joint in final extension after chair egress. The special chair in this case was recommended for subjects with egress problems, especially in preference to a mechanical lifting device chair where muscle strength would be allowed to decrease and which tended to leave the subject unbalanced at the end of egress.

In conclusion, it is not clear that chair design adequately provides greater ease in the sit-to-stand action. Also, such chairs are expensive and might not be readily available, even if their efficacy could be demonstrated. A preferable clinical approach would be to provide a movement strategy that afforded easier egress from standard chair designs.

### 3. The Role of Foot position in the Sit-to-Stand Movement

It is important that the feet are in a position that allows for good standing balance once egress is over. The change in posture from sit-to-stand ends with a momentary balanced stand while the subject prepares to make the next movement action. Arcan, Brull & Simkin (1976), observed younger male students during barefoot standing and found that 45-65% of their body weight was carried through their heels, while 30-40% was on the forefoot and 1-9% was on the midfoot. When subjects wore shoes, 40-60% of weight was on the heels, 39-52% was on the forefoot and midfoot weight was again close to zero. When a subject with flat feet was observed barefoot, 60% of the weight was through the forefoot, 26% was on the heel and 15% was on the midfoot. Shoes in this case were found to correct the load, shifting the midfoot weight and redistributing it unto the heels.

Using various foot positions and a force platform Kirby, Price & MacCleod (1987), determined from postural sway which foot position gave the most stable standing position. Subjects were barefooted and data were collected for 20 seconds. The foot position which gave the least amount of anterior-posterior and medial-lateral travel was toes out 25 degrees and one foot placed 30 cm forwards or backwards of the other.

Once the subject is up in the standing position the two most important muscles seen to resist an external force are the tibialis anterior and the gastrocnemius. From the values of integrated electromyography EMG, these muscles can be seen to increase their output 6-18 times in response to increasing external forces (Kobazashi & Matsui, 1976).



In conclusion, it appears to be best if subjects wear their own shoes which can be used to correct some underlying but virtually unnoticeable problem. Foot position used by subjects in standing and presumably sit-to-stand actions may be part of the strategy that the subject has learned to use to overcome a problem (for example, adapting a wider base of support to overcome inadequacies in balance). Therefore, while trends can be suggested, they are not necessarily good for all subjects equally. Clearly, however, foot position in standing is important and, as previously noted, specially-designed chairs do not always allow for adequate manipulation of foot position. Again the disadvantages associated with specially designed chairs lead one to consider the desirability of developing movement strategies that take advantage of subjects' adaptability to already-existing, normal environments.

## INSTRUCTIONAL METHODS

In the clinical setting, the main methods of instruction are verbal, demonstration and written. Nursing and paraprofessional staff face continual teaching situations, trying to encourage and support patients learning to care for their healing bodies or improve their disease process. Most medium sized hospitals do have video-cassette recorders for staff and patient teaching programs and do make use of this teaching medium. In this review the advantages and disadvantages of personal versus technological presentation will be discussed. Studies focussing on learning by observation are then presented.

## 1. Verbal versus video

Instructions given to subjects involved in experimental and clinical procedures are important. It is necessary for the subjects or patients to have precise and accurate information so that they may fulfil task expectations. Performance error may occur, for example, if a subject is given too much or too little information for his experimental level or if different voice intonations emphasize different words, causing the subject to perceive the instructions slightly differently. If a number of testers are used, each brings specific idiosyncrasies such as different timing, ways of stressing words and differing amounts of eye contact. All these factors may affect the experimental or clinical results.

Use of a mechanically produced tape standardizes the verbal instructions given to each subject. Each subject was given exactly the same instructions, presented in exactly the same manner, as each other subject in her experimental level. Also, if the instruction is visual it moderates the tendency for task instruction to produce mechanical responses. However, when instructions were taped, subjects were found to follow them too mechanically and did not generate their own personalized images. The key factor is to allow an active mental process to take place and this more readily occurs during non-directed instructions.

The literature in this area deals with young subjects learning novel or intricate more advanced parts of specific sports skills. The videotape is used in a situation where feedback or knowledge of results is given after one performance and, before the performer gets another practice. Feedback is defined as information available to the learner regarding performance (Rothstein & Arnold, 1976). Feedback is seen by some authors as the single most important variable in learning

and performance of a motor skill (Bilodeau & Bilodeau, 1961 and Fitts, 1964). Feedback may be either intrinsic or augmented. Intrinsic feedback is available from the actual performance of the activity, whereas the augmented type is available from the observer or a videotape.

Rothstein and Arnold (1976) reviewed 50 papers dealing with videotape feedback. It was found that in studies which used videotape and cues from the instructor, the results had a 140% chance of being significant when compared to videotape alone. It was thought that the performers were presented so much information on videotape that they had difficulty extracting the relevant cues for themselves. This paper also found that shorter studies have only 15% chance of producing significant differences compared to longer ones. For novel task performers a five week intervention period was recommended, for the subjects to derive benefit. The variables of age, sex and skill level were not found to affect the significance of the studies, where age was Grade 5 to college and skill levels were beginners and intermediates.

## **2. Observational Learning**

Subjects can learn by watching other performers (generally one thinks of a novice watching a skilled performance) or watching replays of their own performances. During observational learning, the information that is presented by the model has to be transformed into cognitive forms so that the viewer has the internalized model necessary to reproduce the action. When one thinks of using observational learning, it is to help in the acquisition of a skill or to develop performance skills (Carroll & Bandura, 1985). Bandura (1977, 1981) proposed that observational learning was a multiprocess theory and, for acquisition, four processes must be

involved.

The first stage is what is attended to during the modelled performance. It is known that the models present more information than can be processed effectively (Newell, 1981). Therefore, there has to be some method of focussing the observer's attention on the critical features of the performance. The second stage is that the observer has to pay adequate attention to the performance so that it can be internalized and retained. The cognitive activities that aid the representational development are symbolic coding and cognitive rehearsal (Carroll & Bandura, 1985). The third level is that of behavioural production. This production involves a conception matching process in which feedback from the action is compared against an internal model (Carroll & Bandura, 1985). If the modelled behavior has spatial and temporal features which are easily discerned, encoded and cognitively rehearsed, accurate reproductions can be achieved with little or no overt practice or response feedback (Bandura & Jeffery, 1973). If the modelled activity is more intricate and does not translate well from cognitive representation into action (as might be in the case for sit-to-stand) then overt performance is needed to detect mismatches between performance feedback and conception (Martens, Burwitz & Zuckerman, 1976). The final factors are motivation and incentive. These can be used to aid observational learning and performance and the motivators may be extrinsic, vicarious, or self-generated by means of internal standards (Bandura, 1984).

When the observer watches a modelled action via video there are some aspects of the task that cannot be seen because they are out of the field of vision of the camera. Similarly, for subjects learning golf or tennis strokes, part of the movement pattern is outside their field of vision as they perform it. If part of the movement is not seen during observation or performance then the subject does

not have all the necessary information to construct an adequate representation. Carroll & Bandura (1982) showed that complex movements could be enacted better if subjects watched the movements from different views, therefore gaining a more complete representation. If subjects are given feedback showing them their performance, it was found that the following performance improved significantly if the camera angle was kept the same as that showing the skilled models performance. Comparisons of the internal model and the ability to make corrections of the movement were more focussed if the camera angle was constant.

Some time spans have been shown to be critical to the observers performance. After the observer has watched the skilled model's performance, the time immediately following is important because a period of rehearsal is needed. The patterns are rehearsed so that the action patterns maybe subjectively organized or recoded into linguistic and imaginal mnemonic aids designed to facilitate recall. The repetition itself is also used to enhance retention by increasing the strength or number of memory traces (Bandura & Jeffery, 1973). Subjects given inter-trial activities do not retain the memory traces as well. The timing of the visual feedback was found to be crucial in the subjects learning a new task especially where some of the movement was outside the visual field. Carroll & Bandura (1985) found that concurrent visual monitoring (especially where the views were those not normally seen) greatly enhanced one's enactments of the observationally learned skill.

In conclusion, instructions are necessary to teach a subject who is observationally learning a task. Instructions maybe verbal, visual or a combination of these. Some of the main aspects of observational learning for a visual model rest on allowing the observer to see as much as possible, giving time to internalize what

has been seen and a possible chance to re-enact the performance. The replay, if used as a means of feedback, is best shown concurrently so that the subjects can update the internal model.

### **3. Mental versus Physical Practice**

Mental Practice (MP) is considered to be a very important adjunct to physical practice (PP) in terms of skill acquisition. MP is the "symbolic rehearsal of a physical activity in the absence of any gross muscular movements" (Richardson, 1969, p.95). Alternatively, Marteniuk (1976) has defined MP as "Improvement in performance that results either from the individual thinking about the skill or from watching someone else performing it" (p.224). Mental imagery (MI) is considered a component of MP and is probably a major one (Hall, 1985). MI is cognitively reproducing or visualizing an object, scene or sensation as though it were occurring in overt physical reality (Warner & McNeill, 1988). MP, therefore, can be considered to be the repetitious use of MI (eg. practicing a physical movement mentally) to achieve a result.

Clinically, MP does not appear to be used by many professional staff. It is conceivable that speech therapists could use it to help stutterers envision the smoothness of speech flow. Most other staff in a teaching situation (e.g. practicing stump bandaging) demonstrate and then insist on the patient practicing. Another alternative would be to demonstrate and then give the patient a bandaging diagram and let him or her mentally practice before physically practicing. Orthopaedic patients in long leg casts have been advised for the past few years to practice all their knee and foot range of motion exercises inside the cast. This could be considered a form of mental practice as no overt movement is taking place. The

benefits of this exercise regime are thought to be: better range of motion; more muscle strength and less muscle wasting when the cast is removed.

In physical therapy, only one study using MP has been reported. Fansler, Poff & Sheppard (1985) used MP and MI to enable elderly women to improve their standing balance times. Thirty-six females over the age of 70 were assigned to one of three intervention groups: group A was a control, group B was relaxation and group C was ideokinetic facilitation (MI). There was a three day intervention period where subjects listened to their respective tapes and were given 3 PP trials. They were advised not to practice on their own or to discuss their tape. Equipment used was a pressure switch taped to the bottom of the lifted shoe in which both lifting the shoe and floor contact caused a deflection on the time trace paper read out. Results compared one-legged balance times on the initial day to the final day. Only group C showed significant improvement in measures: therefore MI was seen as improving the elderly subjects balance times.

MP is not a substitute for PP but used in combination, performance has been shown to be greater than in control groups and in some cases as great as in groups with 100% PP. The combination of MP and PP in the proportions of 50% MP and 50% PP was found to be effective for the teaching of a volleyball pass (Johnston, 1971). Weinburg (1982) found that the combination of the two practice techniques which produced the greatest change in the subjects' performance was a function of the type and difficulty of the task, the subject's level of ability and other variables that are at the present time unknown. Other work suggests that subjects who were able to focus on strong visual performance, imagining perfect movements and positive results of the task, were successful with MI.

Breitling, Guenther, Rondot, (1986) showed that subjects practicing MI during electroencephalography (EEG) increased activity in the brain not only in the visu-

al processing area but also in areas involved in movement execution. Feltz & Landers (1983) reported that the MI practice did not replicate the pattern generated during PP when muscle activity patterns in athletes during PP of a specific movement were compared to subjects practicing the movement through MI. Muscle activity in the fixators and synergists, for example, throughout the whole body was reproduced, however. MP prepares for good performance by increasing the general activation level of focussing the subjects attention and by preventing disruptive or negative thoughts. In team sports, it has been suggested that injured athletes can use MP while watching drills done by their active teammates out on the court or on the field, thereby learning and maintaining skill.

Hall (1985) wished to control and maximize the response to MI and, therefore, enable all subjects to respond more uniformly to the stimulus received. He concluded that there were two types of imagery - visual and kinesthetic. The first involves visualizing a very vivid picture of the scene, the second involves the imagining of how the movement feels without performing it. The study concluded that three related variables could be used to control imagery and decrease the amount of individual differences. First, the subject had to be able to produce an adequate measure of motor MI (as determined by a questionnaire inventory). The second factor, is that the task to be performed should definitely benefit from the use of imagery. Finally, the imagery instructions should ensure that all the subjects are imaging the task in exactly the same manner regardless of their individual abilities.

MP is thought to be especially effective in the initial phase of skill learning where learning is thought to be more cognitive than motor. The MP helps the learner construct a better 'schema' of cognitive elements of the task. The role of the instructor is to provide cues that maximize the probability of the learner gener-



ating the appropriate images during the MP sessions. 'Shaping' imagery accurately is possible through detailed verbal instructions or, in some cases, with direct exposure of the subjects to an external model (Dennis, 1985).

In the later stages of learning, MP involves visual imagery which relies on an 'internal model'. This means that the whole process becomes less visual and relies more on smoothing and perfecting the intricacies of the gross movement pattern. Norris (1986) in an article on biofeedback, stated that whether we are learning to decrease our blood pressure, learning to walk, or ride a bicycle, we are not training our bodies but our brains. Believing in one's mind, that one's body can do more, is a powerful mental training tool. In 1954 when Roger Bannister became the first person to run the mile in less than four minutes, MI was said to be the means which allowed him to surpass the existing record (Warner & McNeill, 1988).

Studies which have reported no significant results with MP were found to have one of two major flaws: 1) All MP sessions were conducted on the same day; or, 2) studies used audiotaped or directed instructions of MP. Warner & McNeill (1988) stated that for optimal results MP sessions should be conducted on separate days, the duration depending on the task to be improved or learned.

In conclusion, MP is considered an effective means of training the mind and, therefore, the body. Although most papers present MP as a method of training novices skill performance, it has also been effective even in training at Olympic skill levels (Suinn, 1976). Task considerations in terms of cognitive and motor involvement, visual and kinesthetic imagery and percentage of MP to PP, are all important in terms of how the outcome of MP enhances the physical skill. Cognitive tasks showed greatest improvement after MP in the shortest period of time, improvement of motor skill was less dramatic and more trials with longer sessions

were needed (Feltz & Landers, 1983). The most important aspects of the task have been shown to be the subject's ability to produce a totally vivid image, to be able to transform themselves into the image, to feel and see the movement as if in real life, and to pay attention to the critical points of the task as guided by the instructor.

Few, if any, Physical Therapists, at the present time use MI or MP. As indicated through this review, there is a large untapped potential use for these techniques. MI and MP require no special equipment and are easily taught and learned. Through regular use, "patients may be assisted to speed up their physical recovery, create a greater ease of performance, enhance their mental clarity, reduce stress and create a sense of serenity" (Warner & McNeill, 1988, p520). MP allows patients to visualize themselves performing physical movements in real-life situations, to practice easily and to envision perfect outcomes even beyond what is generally believed possible by the patient. For those who find PP difficult, MP represents a potentially useful means of improving even well-learned activities such as sit-to-stand.

### Summary of the Literature

The sit-to-stand movement pattern has been analysed biomechanically (Kelly et al, 1975). It has been found that all subjects use a relatively constant, innate pattern with a few of their own minor idiosyncrasies. All subjects do have the ability to adapt their movements if necessary ( e.g. if the ankle is put in a cast, if low back pain exists, or if limited accessibility is the case). Certain factors such as some pathologies and chair designs were shown to make the movement more difficult (Wheeler et al, 1985; Burdett et al, 1985; Clarke & Faletti, 1985). In contrast, a seat height of 150% of the calcaneo-tibial length (Nauman et al, 1982), decreased the shear force on the knee and presumably reduced the moment of force. Other factors that were stated to aid the movement were the provision of enough room under the seat so the feet could be put back (Wheeler et al, 1985), thus allowing the subjects to wear their own footwear rather than being barefooted.

Instructions used to communicate the desired movement to subjects are important. Bandura and colleagues (1973, 1974) have demonstrated the efficacy of observational learning. Most of this work has been used in teaching younger adults sports skills in novel learning situations. The mental practice research cited also relates mostly to this category of learner with only one study, that by Fansler et al (1985) involving the use of older subjects. Several questions arise from these findings in the literature.

First, using older subjects performing the sit-to-stand movement, is it possible to make them change their movement pattern through the use of types of instruction and types of practice? Assuming each individual uses approximately the same movement pattern with his or her own added idiosyncrasies, can the use of

a few basic instructions help subjects to achieve the standing position with less force? Research evidence (Kelley et al, 1975) has found that the peak moments of force around the hip and knee occur at the point where the buttocks are lifted off the seat. Previous research by Attridge (1988) showed that maximum force in the Z direction of the Force-Time curve occurred at the time when the buttocks were lifting off the seat. (This was also suggested by the Y F-T curve crossing the zero line after the unloading of the body weight during the preparation for standing.) Since the maximum Z force is critical to being able to perform the push up that ultimately gets one out of the chair, if that critical effort is reduced, subjects would become more effective in their movement.

Second, are there differences between older adults and younger ones (on whom most research has been conducted)? Are the principles governing standard applications of instruction and practice as appropriate for elderly subjects as for younger ones? This work attempted to find the answers to these questions.

## CHAPTER 3

### Statement of Problem

The problem addressed in this study is to ascertain how the peak vertical (Z) force produced during the sit-to-stand movement can be most effectively reduced. Two questions underlie this main theme. First, how do older and younger subjects differ in their reaction to the 2 instructional methods, (these being video and verbal versus non-verbal). Are both methods equally effective? Second, how do older and younger subjects differ in their reaction to the 2 practice techniques, (these being 50% mental and 50% physical practice versus 100% physical practice)? Is one method is more successful than another?

## CHAPTER 4

### Methods

#### 1. Dependent Variables

The dependent variable used for subject information (Knowledge of Results, or KR) and for data analysis in this study was the peak force in the vertical (Z) plane. As was stated earlier, this was seen to be the critical variable that determines successful or unsuccessful standing from the seated position. An Advanced Mechanical Technology Inc. (AMTI) force plate was the system used to collect the data using the Computer Automated Gait (CAG) software package. This allowed the necessary variable time periods and range of intervals over which to collect the data.

Dependent variables other than peak Z force were available from each trial's CAG output. For example, impulse was considered to be a possibly useful parameter to investigate. However, it was generally not found to vary more than 5-6 Nsec (max. 10 Nsec). Since impulse is Force x Time (always 3 sec), this value was largely determined by body weight and there was no meaningful pattern to results over trials. The X and Y forces were also available from the force plate data. The Y force (in the A-P body movement plane) could be used in the initial 2 pre-test trials to recognize the Centre of Mass (C of M) of the body moving downward and forward to its lowest point and then rising above the zero axis as the body accelerated away from the force platform. The X forces showed the uneven balance distribution between the right and left feet but this data was not used as

lateral sway would have provided no useful insight. Time intervals for the movement pattern were also considered. Initially, a time measurement from the Z force curve was used to try and recognize where the movement began and ended. For the 2 pre-test trials this was easily recognizable but as the experimental trials progressed, the characteristic landmarks in the curve of loading and unloading became unrecognizable. The other time interval that was measured was time to peak Z force. This time interval was to find if preparation took longer as the peak force decreased. Also, the ratio of time to peak force versus time to stabilization as a measure of efficiency in force production, could be calculated to observe if it changed with trials. These times became impossible to recognise because of the smooth force patterns and often exaggerated sway patterns of the older subjects. In the pilot study (Attridge, 1988) the data collection system was initiated by the software, when a force of more than 13 N was put on the force plate. This gave a consistent start. In this study a manual keystroke was used to initiate data collection: this did not afford the consistency needed to make time measurements of the Force-Time curve. Therefore, peak Z force alone was used to draw conclusions about the effects of the independent variables on the sit-to-stand movement.

## **2. Independent Variables**

Two separate experiments, each with its own subjects, were conducted. For both experiments, the independent variable age, was used as a subject grouping variable. The age variable had 2 levels: the younger subjects were aged 20-30 years and the older subjects aged 65-81 years. All subjects were females with each cell containing equal numbers of old and young.

Also for both experiments, a repeated measure variable, trials, was used to test the effect of practice on peak force Z. In experiment 1 there were 8 levels of the RM variable. Each subject was given 2 recorded pre-test and 6 recorded post-test trials. In experiment 2 there were 10 levels of the RM variable. Each subject was given 2 recorded pre-test trials and 8 recorded post-test trials. The mental practice group started with one mental practice trial and had one physical practice with data collection.

The third variable for experiment 1 was teaching methods. Two levels of this variable were used, verbal and video versus non-verbal. The non-verbal instructions were presented to the subjects in a typewritten paragraph on a sheet of paper and the verbal and video instructions were presented as simultaneous narration and modelled performance on a video monitor.

The third variable for experiment 2 was practice methods. There were 2 levels of this variable, 100% physical practice, and 50% mental practice and 50% physical practice. The 100% PP group was used as the control group. 50% MP combined with 50% PP was chosen so that after each MP trial a PP trial could be recorded and there would be a measurement for comparison with the 100% practice group. Also, Oxendine (1969) showed that a 50:50 combination of mental practice and physical practice produced improvements similar to those of physical practice alone, suggesting that this combination is sufficient to see a mental practice effect if one exists.

### **3. Design and Analysis**

Separate analyses were conducted for each experiment. To test reliability, t-tests were performed on the 2 pre-trials of each subject's data. In each case, the



peak Z force data were analyzed by using a 3 way analysis of variance with repeated measures on the trials variable. A probability level of 0.05 was used as the test of significance. For experiment 1, the design was Age(2) X Instruction Type(2) X Trials (8). For experiment 2, the design was Age(2) X Practice Type(2) X Trials(10).

The peak Z force produced in the sit-to-stand movement was reliant on the subject's body weight and the acceleration of the centre of mass of the body off the chair in the vertical (Z) direction. To normalize for body size, the ratio of force above body weight divided by body weight was used in all analyses.

#### **4. Statements of Hypotheses**

The following main and interaction effects resulted from the designed manipulations of the independent variables and represented the testable hypotheses in Experiments 1 and 2. Both null and alternative hypotheses are listed.

##### **Experiment 1**

Hn(1) Younger adults will not produce different peak Z forces than older adults.

Ha(1) Younger adults will produce different peak Z forces than older adults.

Hn(2) The non-verbal instructional method will not produce different peak Z forces than video and verbal.

Ha(2) The non-verbal instructional method will produce different peak Z forces than video and verbal.

Hn(3) Peak Z force will not be affected by practice (trials).

Ha(3) Peak Z force will be affected by practice (trials).

Hn(4) Younger adults will not produce different peak Z forces than older adults in response to different instructional methods.

Ha(4) Younger adults will produce different peak Z forces than older adults in response to different instructional methods.

Hn(5) The effect of practice (trials) will not be affected by age.

Ha(5) The effect of practice (trials) will be affected by age.

Hn(6) The effect of practice (trials) will not be affected by the type of instruction given.

Ha(6) The effect of practice (trials) will be affected by the type of instruction given.

Hn(7) The effect of practice (trials) will not be affected by the type of instruction given depending on whether the subjects are older or younger.

Ha(7) The effect of practice (trials) will be affected by the type of instruction given depending on whether the subjects are younger or older.

## Experiment 2

Hn(1) Younger adults will not produce different peak Z forces than older adults.

Ha(1) Younger adults will produce different peak Z forces than older adults.

Hn(2) Mental practice technique will not produce different peak Z forces than physical practice.

Ha(2) Mental practice technique will produce different peak Z forces than physical practice.

Hn(3) Peak Z force will not be affected by practice (trials).

Ha(3) Peak Z force will be affected by practice (trials).

Hn(4) Younger adults will not produce different peak Z forces than older adults in response to practice technique.

Ha(4) Younger adults will produce different peak Z forces than older adults in response to practice technique.

Hn(5) The effect of practice (trials) will not be affected by age.

Ha(5) The effect of practice (trials) will be affected by age.

Hn(6) The effect of practice (trials) will not be affected by the type of practice given.

Ha(6) The effect of practice (trials) will be affected by the type of practice given.

Hn(7) The effect of practice (trials) will not be affected by the type of practice given depending whether the adults are older or younger.

Ha(7) The effect of practice (trials) will be affected by the type of practice given depending whether the adults are older or younger.

## **5. Subject Selection**

Twenty-four female subjects were used in each of the two experiments. Twelve subjects were in the young age group (20-30) and twelve were in the older age group (65-81). All the subjects, young and old, were from an independent living

situation and all stated that they had no problems performing the sit-to-stand movement, under normal circumstances.

## 6. Equipment

A chair that could be set on the force plate was constructed so that all forces applied to the chair and the feet could be recorded. The dimensions of the chair were: seat height, 39 cm; depth, 27 cm; width, 47 cm; and, the height of the back above the seat, 35 cm. The weight of the chair was 51 N. Chair height could not be adjusted but knee angle while sitting was adjusted to 70 degrees. This was done by using a block of wood (weight = 27 N) on a non-skid polymer placed under the subject's feet. This ensured that subjects of different sizes did not have a mechanical advantage or disadvantage due to different starting angles of the knee while seated.

An Advanced Mechanical Technology Inc. force plate of dimensions 51cm X 46.5 cm and associated North Star computer running two software packages were used to sample the data. First, the power analysis package was used (prior to each testing series) to weigh subjects when seated on the chair. The weight was taken over 1.5 sec with a sampling rate of 100 Hz. The computer automated gait (CAG) software was used to record standing data for further statistical analysis. The CAG program was instructed to record the data onto the disc at 50 Hz for 3 sec started by the touch of a key stroke. The dependent variable recorded was peak force in the Z plane (upward). The forces were measured by foil strain gauges attached to load cells at the four corners of the platform. These gauges produced three output voltages proportional to the X,Y and Z forces and three proportional to the moments X,Y and Z. Although the true origin of the X,Y and Z

are actually found at the geometric centre of the force plate, a certain distance below the surface of the force plate, calibration determined the force relative to the surface of the plate. Forces were determined by calculation of vectors in the X,Y and Z direction. Calibration using a known weight demonstrated that the force plate performed within  $\pm 0.95\%$  accuracy when using the Power program and  $\pm 0.97\%$  using the Computer Automated Gait program.

Non-verbal commands, where appropriate, were given on a typed sheet for subjects to read for themselves. For subjects receiving the video and verbal commands, where appropriate, a pre-recorded tape was shown to each subject. The video camera was a Panasonic flying erase head with variable shutter speed and an auto-focus lens, model number AG-170. The colour video monitor was a Panasonic BT-S1900NC with a 22 inch screen.

## **7. General Procedures**

Upon arrival in the laboratory, subjects were assigned to one of two testing groups. For experiment 1, one group was called "Non-verbal" while the other was "Video and Verbal Feedback". For experiment 2, the groups were "Mental Practice" or "Physical Practice".

All subjects were initially seated on the chair on the force plate and the knee angle was measured and adjusted to 70 degrees. Using the power analysis software the subject was weighed in the seated position. The subjects were then asked to perform 2 trials of sitting to standing using their normal movement pattern. These trials were performed without detailed instructions. It was emphasized, however, that both feet had to remain on the force plate throughout the entire trial and that they would have to stand on the force plate until the computer tone at the end of the 3 sec data collection time signified the end of the trial.

In this study the video and verbal versus non-verbal instructions were purely a single time instructional technique. The subjects were all highly familiar with the movement task required. The instructional method was used to indicate the purpose of the task and highlight a few of the main task components.

### **8. Procedures specific to Experiment 1**

Following group assignment, weighing and the initial two pre-test trials, subjects received task instructions appropriate to their groups. Subjects in the "Non verbal" group were given a script to read and subjects were allowed to take as much time as they required to read it. The script said:

" These are your instructions: You are presently seated in a chair with your knees bent to about 70 degrees, your hands resting lightly on your thighs and sitting right back against the back rest, this is the starting position. To rise out of the chair you can move your hands and feet to any position you need. There are only two conditions, you must not push up with your hands and you must keep your feet on the force platform. It is best if you move forward and try to stand up really gently or softly so that you are not using a lot of force. Remember stand up really softly! When you have stood up you will have to stand still for a second or two, until the computer has beeped and we know that it has finished recording."

The Video and Verbal Feedback group were shown a subject performing the task as seen from a direct sagittal view with the same instructions being read to them as had been read by the other group. Upon completing this instructional phase, all subjects were allowed to ask questions to clarify matters not made clear by the script or the video.

Both groups of subjects were told that after performing each sit-to-stand movement, the data file recording that particular trial would be reviewed and the sub-

jects would be told a number representing the peak (maximum Z) force they used. Subjects were told that to stand up ' more softly' each time would result in this number decreasing each time. A total of 6 trials post-intervention were given to each subject after each one knowledge of results was given.

### **9. Procedures specific to Experiment 2**

Following group assignment, weighing and the initial two pretest trials, subjects were shown the verbal and video instructions as used in experiment 1. Upon completing this instructional phase, all subjects were allowed to ask questions to clarify matters not made clear by the script or the video.

Both groups of subjects were told that after performing each sit-to-stand movement, the data file recording that particular trial would be reviewed and they would be told a number representing the peak (maximum Z) force they used. Subjects were told that to stand up ' more softly' each time would result in this number decreasing each time. A total of 8 trials post-intervention were given to each subject after each knowledge of results was given.

The physical practice group then proceeded with eight physical practice trials with knowledge of results being given after each trial. The mental practice group started with a mental practice trial consisting of sitting in the chair with eyes closed and following a mental imagery protocol as led by the experimenter. These instructions consisted of the following guiding comments:

'You are sitting up really straight in the chair and you want to get up really softly, using as little force as possible. Think about moving forward in the chair, lifting your hips off real easy, letting your knees straighten up. Think of being as light as a feather, floating up into standing. Once you are standing straight, stay still until the computer tone.'

After each mental practice trial subjects had a physical practice trial for which data were recorded. This pattern was continued until a total of 8 PP trials was recorded, resulting in 8 MP trials as well.



## CHAPTER 5

### RESULTS

#### 1. Experiment 1

For paired t-tests for trials 1 and 2,  $t(23) = -0.62$ ,  $p > 0.05$ . For correlations between the results of the trials 1 and 2,  $r = 0.83$  and  $R^2 = 0.68$ .

A 3 way ANOVA (age x practice method x trials) with repeated measures for trials was used for statistical analysis of the data for this experiment. The level of probability considered to be significant was 0.05. Descriptive statistics for cell means are shown in Table 1.

The ANOVA results are shown in Table 2.

A significant result was found for the main effect of trials ( $F_{7,140} = 31.57$ ,  $p < 0.05$ ), thereby the null hypothesis  $H_0(3)$ , peak forces will not be affected by practice (trials), was rejected.

The interaction effect between age and trials was also significant ( $F_{7,140} = 3.37$ ,  $p < 0.05$ ), thereby the null hypothesis  $H_0(5)$ , the effect of practice (trials) will not be affected by age, was rejected. The results are portrayed graphically in Figure 2.

The following null hypotheses were accepted:

$H_0(1)$  Younger adults will not produce different peak Z forces than older adults.

$H_0(2)$  The non-verbal instructional method will not produce different peak Z forces than video and verbal.

$H_0(4)$  Younger adults will not produce different peak Z forces than older adults in response to different instructional methods.

$H_0(6)$  The effect of practice (trials) will not be affected by the type of instruction given.

Hn (7) The effect of practice (trials) will not be affected by the type of instruction given depending on whether the subjects are older or younger.

## 2. Experiment 2

For paired t-tests of the 2 pre-test trials,  $t(23) = 0.78$ ,  $p > 0.05$ . For correlations of trials 1 and 2,  $r = 0.71$  and  $R^2 = 0.51$ .

A 3 way ANOVA (age x practice methods x trials) with repeated measures for trials was used for statistical analysis of the data in this experiment. The level of probability considered significant was 0.05. Descriptive statistics for cell means are shown in Table 3.

The ANOVA results are shown in Table 4.

A Significant result was found for the main effect of trials ( $F_{9,180}=58.53$ ,  $p < 0.05$ ), thereby the null hypothesis Hn (3), peak force will not be affected by practice (trials), was rejected.

Three significant interaction effects were also seen: a two way interaction of age and trials ( $F_{9,180}=5.04$ ,  $p < 0.05$ ), thereby the null hypothesis Hn(5), practice (trials) will not be affected by age, was rejected; the two way interaction of age and practice type ( $F_{9,180}=6.05$ ,  $p < 0.05$ ), thereby the null hypothesis Hn (4), younger adults will not produce different peak Z forces than older adults in response to practice technique, was rejected ; and, the three way interaction effect of age, practice method and trials ( $F_{9,180}=2.53$ ,  $p < 0.05$ ), thereby the null hypothesis Hn(7), the effect of practice (trials) will not be affected by the type of practice given depending on whether the adults are older or younger, was rejected.

The results are portrayed graphically in Figure 3.

The following null hypotheses were accepted:

Hn(1) Younger adults will not produce different peak Z forces than older adults.

Hn(2) Mental practice technique will not produce different peak Z forces than physical practice.

Hn(6) The effect of practice (trials) will not be affected by the type of practice given.

<b>Instructions</b>	<b>Older Adults</b>	<b>Younger Adults</b>	<b>Totals</b>
<b>Non verbal</b>	0.111	0.150	0.131
<b>Verbal-Visual</b>	0.153	0.160	0.157
<b>Totals</b>	0.132	0.155	0.144

Table 1. Mean values for normalized peak Z force for age groups and instructions

Anova table for a 3-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Condition (A)	1	.03	.03	1.02	.3253
Age (B)	1	.02	.02	.77	.39
AB	1	.01	.01	.4	.5368
subjects w. groups	20	.64	.03		
Repeated Measure (C)	7	.23	.03	31.56	.0001
AC	7	3.89E-4	5.56E-5	.05	.9998
BC	7	.02	3.45E-3	3.37	.0024
ABC	7	4.98E-4	7.12E-5	.07	.9995
C x subjects w. groups	140	.14	1.02E-3		

There were no missing cells found.

Table 2. Analysis of Variance table for Experiment 1

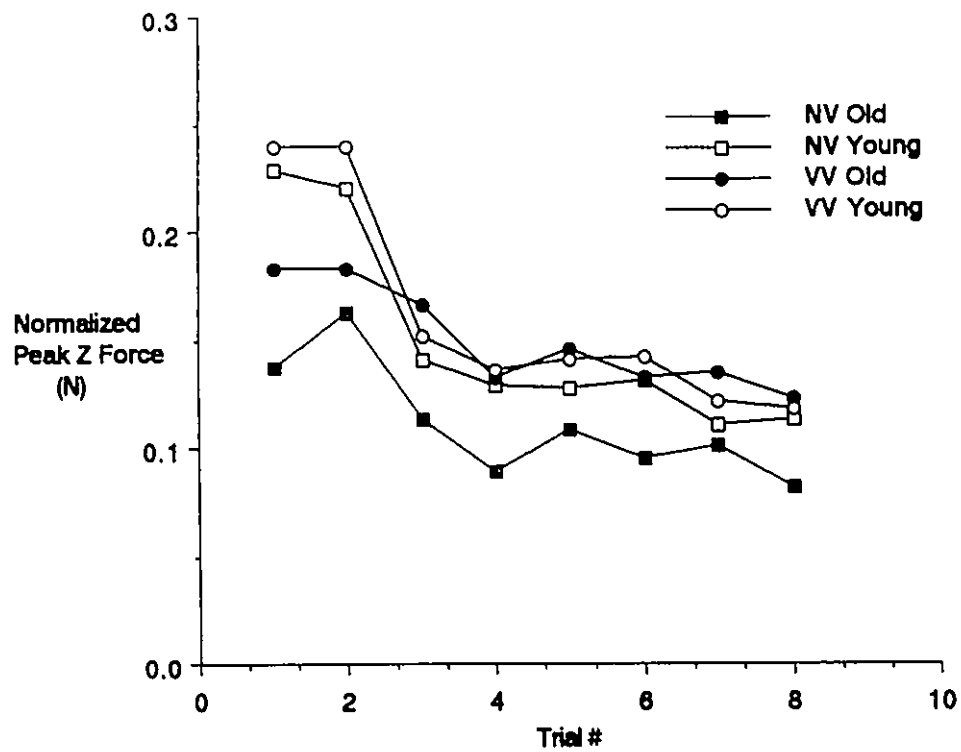


Figure 1. Normalized Peak Z Forces for Instructions and Age Groups in Experiment 1

<b>Practice Type</b>	<b>Older Adults</b>	<b>Younger Adults</b>	<b>Totals</b>
<b>Mental</b>	0.130	0.122	0.126
<b>Physical</b>	0.104	0.159	0.132
<b>Totals</b>	0.117	0.141	0.129

Table 3. Mean values for normalized peak Z force for age groups and practice type

Anova table for a 3-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Practice Type (A)	1	1.77E-3	1.77E-3	.18	.8777
Age (B)	1	.03	.03	3.4	.0802
AB	1	.06	.06	6.05	.0231
subjects w. groups	20	.2	.01		
Repeated Measure (C)	9	.48	.05	58.53	.0001
AC	9	.01	1.26E-3	1.45	.1715
BC	9	.04	4.41E-3	5.04	.0001
ABC	9	.02	2.21E-3	2.53	.0094
C x subjects w. groups	180	.18	8.73E-4		

There were no missing cells found.

Table 4. Analysis of Variance table for Experiment 2



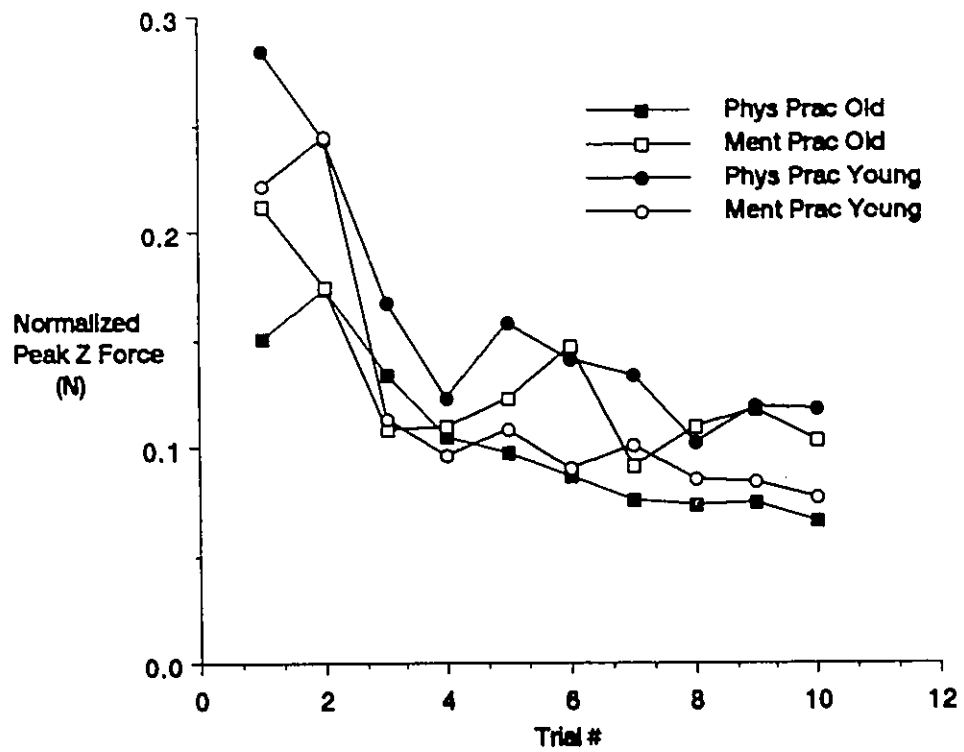


Figure 2. Normalized Peak Z Forces for Practice Type and Age Groups in Experiment 2

## CHAPTER 6

### DISCUSSION

#### Purpose of Study

This study examined the ability of adults to learn to change the peak force used during the performance of the sit-to-stand movement. To accomplish this, two experiments were conducted. The experimental design chosen in each case was to test two groups of females, one group in the age range 20-30 and an older group in the age range 65-81, performing the sit-to-stand movement under two types of conditions. The first experiment examined the effect of varying teaching methods (verbal and video versus non-verbal) while the second examined the effect of varying practice techniques (100% physical practice versus 50% physical practice and 50% mental practice).

From a clinical point of view, the literature (and practical experience) indicates that the sit-to-stand movement is important because an individual cannot achieve an independent status without it (Burdett et al, 1985). The focus of many previous studies (Burdett et al, 1985; Clark & Faletti, 1985; Wheeler et al, 1985) has been chair design but this is only a partial solution. Only institutionalized patients are set out in the exact same chair every day. Independence requires the need to move about and successfully complete egress from a number of potential sitting surfaces. This study took a generalized approach to the problem of egress, investigating some factors thought to affect the ability to lower the critical peak Z force that allowed them to achieve successful egress. By identifying the ways in which desired changes in egress can be produced, the study attempted to contribute both to clinical practice and also to our understanding of

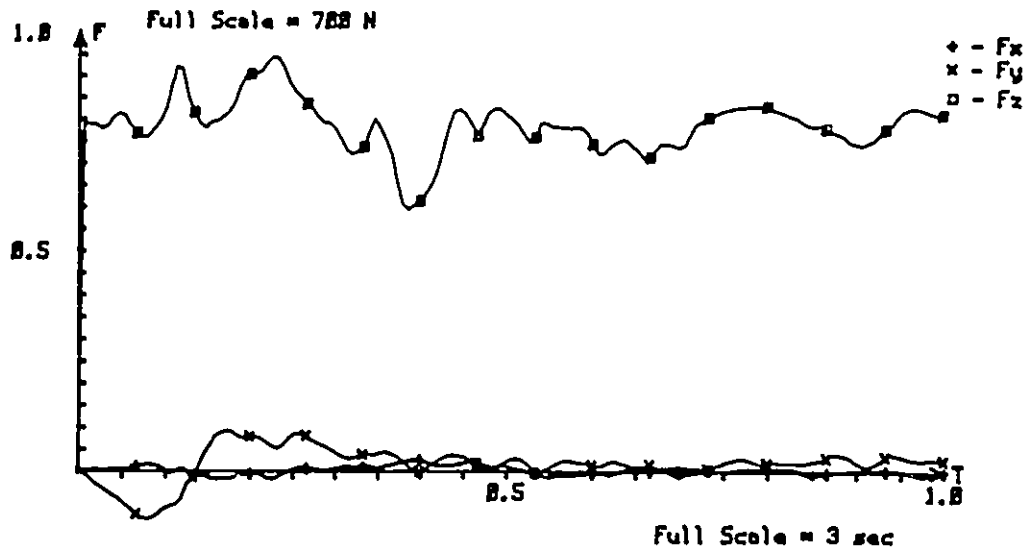
how the elderly learn and perform day-to-day tasks.

### **Delimitations of the Study**

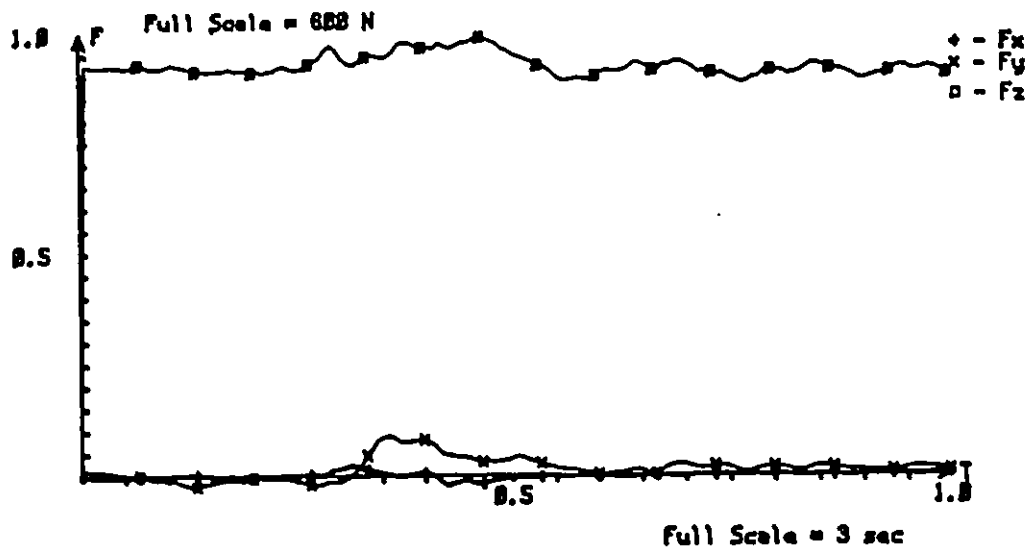
The only dependent variable that was used to analyze the results was a ratio of (peak Z force - body weight)/body weight. The peak Z force was seen to be the crucial force that the subject needed to muster in order to get out of the chair successfully. In this study as well as a previous pilot study (Attridge, 1988), the peak Z force was seen to occur after the preparatory phase, where the centre of mass of the body stopped moving forward and downward and started to rise, as the buttocks lifted off the seat. The ratio was devised so as to nullify the direct relationship of peak Z force to body weight. The effect is to normalize all performances so that body weight is minimized as a factor contributing to the assessment of sit-to-stand performances. Also, timing characteristics were not easily determined from data records of subjects after initial phases of practice (see Figure 3 for a comparison of timing landmarks before and after practice).

All subjects recruited to the experiment were chosen because they fitted certain criteria. Specifically, the 3 criteria were that they were the correct age; came from an independent living situation; and, declared that they would have no problem performing approximately 15-20 sit-to-stand movements in a row. The 24 subjects tested in each of the two experiments were 12 older and 12 younger adults each assigned randomly to one of the two experimental groups.

The subjects were examples of 'normal' individuals from the population of both age ranges and it is thought the results are generalizable to other 'normal' samples within the same age ranges. The seat used for testing, although cer-



Averages	Impulses	Maxima	
$X_0 = 3.8 \text{ cm}$	$X = 8.2 \text{ N-sec}$	$F_x = 19.8 \text{ N}$	$N = 158$
$Y_0 = .2 \text{ cm}$	$Y = 21.3 \text{ N-sec}$	$F_y = -81.9 \text{ N}$	$dT = .82 \text{ sec}$
$F_{x0} = 549.7 \text{ N}$	$Z = 1849 \text{ N-sec}$	$F_z = 659 \text{ N}$	



Averages	Impulses	Maxima	
$X_0 = 2.3 \text{ cm}$	$X = 6 \text{ N-sec}$	$F_x = 16.6 \text{ N}$	$N = 158$
$Y_0 = 3.3 \text{ cm}$	$Y = 14.7 \text{ N-sec}$	$F_y = 49.5 \text{ N}$	$dT = .82 \text{ sec}$
$F_{x0} = 552.8 \text{ N}$	$Z = 1658.5 \text{ N-sec}$	$F_z = 591 \text{ N}$	

Figure 3. A comparison of practice trials 1 (Top) and 10 (Bottom) showing differences in timing landmarks

tainly not conforming to the 'standard' variety of chair found in the home, did perform the function of affording all the subjects the same starting position and allowing all the force to be produced on the force platform and therefore recorded. This was not possible using a regular chair.

All subjects especially the older group made comments about the unnatural sitting position, a feature of the experiments demanded by the force measurement system. Starting with the knee angle at 70 degrees and working out range quadriceps (which is the weakest range) was not normal. Most times, the subjects could not put their feet flat on the platform. They were standing up on their toes, initially. The position was rather cramped and if subjects stood up too quickly they bumped the chair off the force platform with the back of their knees. When subjects were seated in a 'normal' chair and asked to comment on what the differences were, most of the older ladies when seated back against the back rest could not touch their feet to the floor. When asked to rise out of the 'normal' chair some changed their minds and said they didn't think it was any harder getting up from the specially constructed chair while others still thought it was easier to get up from the 'normal' chair.

In the video modelled performance only a sagittal view was shown. This was considered to offer more information to the subject than the other views. It is improbable that subjects would have produced any different results if shown a different view since the sagittal view provides all of the relevant task information.

### Experiment 1

The purpose of Experiment 1 was to find which instruction method (video combined with verbal information versus non-verbal teaching) was better for the clinical environment, with reference to the sit-to-stand movement. Also, it was intended to find if the older and younger adults reacted the same to the difference between the types of instructions.

The most important result of the first experiment was that the observational learners did not reduce their peak Z forces any differently than those in the non-verbal group. From the literature review, the video and verbal group might well have been expected to be more efficient, as, they gain a more complete 'motor' picture (Bandura, 1977,1981; Carroll & Bandura, 1985) and were also given clues to direct their attention (Newell, 1981). These apparent advantages, however, did not produce superior learning in terms of peak force reduction for the older or the younger subjects under the experimental conditions provided.

The factors considered important to video teaching are that the view (Carroll & Bandura, 1982, 1985) be sagittal and the cues kept very focused. The sagittal view gives the observer a much more precise image than what a coronal view (mirror directly in front of the subject) provides. In this study, video information from the sagittal view showed the knee and trunk angles and the position of the hands clearly. Also the apparent smoothness and rate of the motion was obvious, although these final two factors were not verbalized to the subjects. The verbal instructions given on the video were exactly the same as those given in the written (non-verbal) instructions group. The instructions drew the observers' attention to; the position of the hands and feet, to the intent that the movement

was supposed to be soft and gentle; and, to the starting action of the body weight moving forward in order to stand up.

The difference between this study and previous research of video instruction lies mainly in the fact that the video was not used as KR. All the other studies presented on instructional methods used the video strictly as KR in a feedback loop situation. In this study the video was strictly used as a one time only, observational learning tool. This may be the key to why the video and verbal group did not outperform the non-verbal group. The sagittal view on the video and the cues did appear to follow previous recommendations for success although in such a well rehearsed routine of sitting-to-standing, the cues deemed necessary were difficult to choose.

All subjects were able to reduce their peak Z forces with repeated trials. It can be seen that after the 2 pre-test trials (whose values were very close and highly correlated), the intervention (teaching) caused the subjects to decrease sharply their peak Z forces. Figure 2 shows this increase in gradients between trials 2 and 3. The other significant interaction effect was that older adults changed their peak Z forces differently to younger adults with practice. This can be explained by observing Figure 2. The younger subjects have a ratio of approximately 0.23 for the initial pre-test condition compared to the older subjects with a ratio of approximately 0.16. By the 8th trial the results have stabilized and the young and old subjects have very similar ratios. It is possibly the case that younger subjects initially 'waste' large amounts of force by bounding off the chair, compared to the older subjects who, from experience, learn to produce only the necessary moderate forces to rise off the chair. In any event these are

clearly age-related differences in the performance of the sit-to-stand movement and in the changes that occur with practice.

In Experiment 1, there was a subject who was tested but did not manage to decrease peak Z forces (Figure 4). This subject admitted later that she was a candidate for total hip replacement surgery. Looking at this subject's results, she did not manage to decrease the forces after the intervention and there was no definite pattern as she grew tired, painful, or bored. Intervention in subjects with specific pathology, therefore, might not be fruitful. These subjects have mastered the movement that is best for them and are not in a position to adapt to a modified method such as the instructional method indicates. Since motivation is an important factor for success in observational learning (Bandura, 1984), it is unlikely that such subjects (or patients) will respond to learning regimes, knowing ahead that they cannot achieve the desired results.

All subjects appeared to use the same strategy to learn the movement pattern required by the instructions. They moved slower. The effect of movement speed, or the rate at which the centre of mass of the body was accelerated out of the chair, is critical in lowering the vertical (Z) ground forces. If the subjects bounced off the chair (as the younger adults did initially), they produced larger forces. With practice they learned to move slower, and therefore decrease the force. The fact that slower movements resulted in lower forces was not suggested to the subjects. Telling the subjects this, would have made the instructional and practice techniques redundant, as the subjects would already have had the knowledge they needed to decrease the forces. Most subjects knew that they were moving slower and all realized that the computer beep from the 3 sec



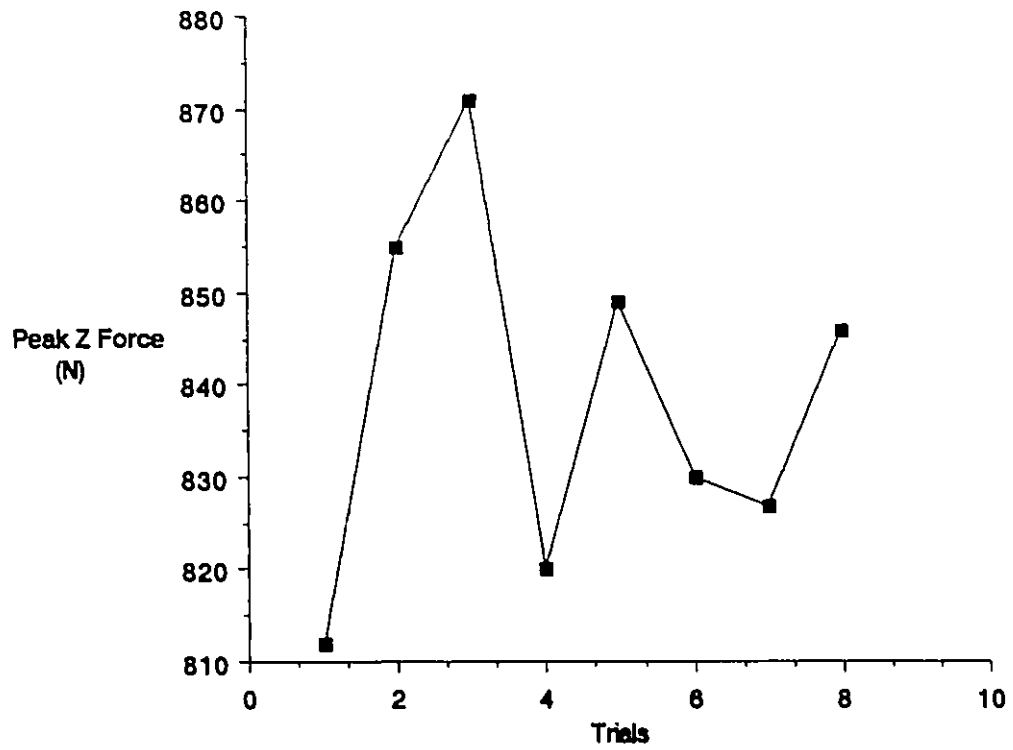


Figure 4. Normalized peak Z forces for subject awaiting total hip replacement

time period was coming earlier in their movement pattern. It would have been interesting if the initiation of the force-time curve could have been made more consistent, in which case the timing characteristics may have shown that the movement did take longer.

A clinical resumé and application of experiment 1 might be that, for the sake of one viewing of the sit-to-stand movement on video with verbal cues, it is not worth the set up time. Subjects appear to be equally proficient in taking verbal or non-verbal instructions. The older subjects had achieved their lowest force ratio by the 4th (or 2nd post intervention) trial. The younger subjects, on the other hand, continued to improve up until the 7th (or 5th post-intervention) trial. This difference can be observed on Figure 2 and might be explained by the fact that the older subjects started with a more moderate force level and didn't have as much force to reduce. The older subjects might also have had more difficulty with the attentional demands, to remember what a certain movement felt like and what force it registered. The slower movement pattern requires greater coordination and muscle control and one might expect a longer pre-movement time. Bandura & Jeffery (1973) stated that simple movements have spatial and temporal features that allow accurate reproduction of the movement with little or no overt practice. This movement does not appear to be that simple. In these terms the older subjects made the transition to the new egress motion more simply than the younger adults.

## Experiment 2

In Experiment 2 the objective was to find if there was any difference between the 50% mental practice and the 50% physical practice compared to 100% physical practice, in terms of reducing the peak Z force. Mental practice is rarely used in the clinical setting (Warner & McNeill, 1988), yet it has many potential uses. In particular, where subjects are slightly unsafe and at risk of falling, they may be restrained to a chair which prevents them from any physical practice of the sit-to-stand movement. Using a college age group allowed for comparison with other studies, in terms of how young people perform. The comparison can then be extended across to the older subjects to observe any differences that might exist between the younger subjects (who have been quite well investigated in studies of mental practice) and older subjects who have not been so well represented in the literature.

The second experiment investigating mental and physical practice found that for the sit-to-stand movement, the 50% mental practice and 50% physical practice was just as effective as physical practice alone. This is an interesting result, as this is only the second reported study using older adults in a mental practice situation (the other being Fansler et al, 1985). Both were successful in demonstrating the efficacy of mental practice in a learning situation. Previous papers had concluded that the mental practice sessions should occur over at least several days. For example, Rothstein & Arnold (1976) suggested 5 weeks for novice performers, Warner & McNeill (1988), suggested 3-4 days and Fansler et al (1985), used a 3 day period with the standing balance study. The study presented here used only a one day intervention period and with only 4 mental

practices and 4 physical practices and still produced the desired result.

The interaction of age and practice techniques was significant. The older adults, therefore, changed their peak Z forces differently than younger adults with practice. If the means of the physical practice conditions are examined, it can be seen that younger adults produce forces that are much greater than the older adults initially. The reasons for this were considered in Experiment 1. When the means for 50% physical and 50% mental practice trials are observed, the older and younger adults means are more similar and in fact under these practice conditions, the older adults have a greater mean peak force than the younger adults. This situation was not seen under the 2 instructional conditions of experiment 1. This is unexpected since, as previously noted, the younger adults produced amounts of force greater than those of the older adults during the initial trials.

One explanation of this difference, is that the mental practice group did not receive the same rest conditions between subsequent physical practice trials. Instead, they were mentally practicing. The mental practice routine, therefore, required concentration as they tried to remember the 'feel' of the motor pattern and relate that to the force platform reading. The attentional requirements to integrate the necessary information may have been more difficult for the older subjects than the younger ones (who were mostly Human Kinetics students and presumably more kinesthetically aware of their bodies).

All subjects were seen to reduce their peak Z forces significantly across practice trials. The greatest changes in forces occurred immediately after the intervention between the second and third trials, with the younger subjects chang-

ing their force ratios by much steeper gradients than the older subjects. The interaction of age and practice trials was significant. Indicating that the younger adults produced different peak force patterns, with practice, than older adults depending on whether they practiced mentally or physically. Figure 3 indicates that the younger subjects expended large forces initially before settling down to lower force levels, whereas the older subjects being more force and energy conscious in their own practiced way, used lower forces initially and had less room for improvement. The results, therefore, are affected by a "floor effect".

The final significant interaction was a 3 way between age, type of practice and practice trials. This indicates that the pattern of peak Z force over trials will be different between older and younger adults depending on whether they have practiced mentally or physically. Observing Figure 3 does not give a clear picture. From the force ratios of trial 1, the younger adults produced the greater forces (with the physical practice group being higher than the mental practice group) than the older subjects (with the mental practice group being higher than the physical practice group). By trial 8 a different pattern had emerged, with the highest force ratios being produced by the young physical practice group followed by the old mental practice group, followed by the young mental practice group, with the old physical practice group using the lowest force ratios. The pattern had reversed. If the change in the ratios (using a mean of the first two trials as the baseline and the mean at trial 8 for comparison) are considered, the young physical practice group decreases its force ratio by 0.125, the young mental practice group by 0.15, compared to the older subjects where the physical practice group changed their forces by 0.57 and the mental prac-

tice by 0.085. The subjects who changed their force ratios the most were the young mental practice group followed by the physical practice group. For the older subjects the physical practice group changed their forces better than the mental practice group.

So far we have considered the results at the 8th post-trial practice: however, at this stage the mental practice group had had 8 physical and 8 mental practices. To find out how the mental practice group was doing at the 8 total trial stage it was necessary to compare the 4th post-test trial (when the subjects have had 4 mental practices and 4 physical practices) to the final 8th physical practice trial. To do this one must observe Graph 2 at trial 6 for the mental practice curve and trial 10 for the physical practice curve. For the young subject group, the mental practice group reached a force ratio equal to that of the final physical practice trial, by the 6th trial. This pattern was not true of the older adults. The mental practice group for the older adults show a large increase in force ratio at trial 6, a rise inconsistent with the surrounding trials (5 and 7). For the sake of comparison, if instead of using the trial 6 mean an average of the means from trials 5,6 and 7. The means would be more similar and therefore we could speculate that the comparison of means between total practice trials (4 physical plus 4 mental) and 8 physical practices would be close.

The strategy used by most subjects was slower movement in order to decrease momentum as discussed in experiment 1. For the mental practice sessions most subjects said they liked to try and focus on the phrases, 'float up into standing' and 'be as light as a feather'. The younger subjects seemed more relaxed with the mental practice routine: for most of the older subjects it appeared

alien. The older subjects had probably been brought up, in the teaching that things must be physically practiced until they are perfect. One 74 year old had to be eliminated from the study because she could not sit on the chair and think about standing up but rather kept on standing and working it out physically.

A clinical resumé and application of experiment 2, might be that using 4 mental and 4 physical practices the subjects appeared as proficient in lowering the force ratios in the sit-to-stand movement as 8 physical practices, in both age groups. However, if we compare mental and physical practices, the younger adults practicing mentally produced lower force ratios than physically practicing. The older subjects did not follow the same trend but achieved lower force ratios by physical practice, not mental practice. One might surmise, that although the older subjects could use mental practice efficiently, they could not lower their forces as well as by physically practicing. If an older subject has difficulty with a movement pattern, it would appear to be well worth the effort of taking the time to teach a mental practice routine.

### **General Observations**

The reduction of peak forces, when observed across trials, appears to stabilize by the 4th or 5th post-test trial. The fact that only 4-5 practice trials were needed, did indicate that the subjects found the new movement pattern relatively simple to learn. According to Bandura & Jeffery (1973) a simple movement with obvious spatial and temporal features requires little or no overt movement practice (on top of an observational learning routine). From a clinical

viewpoint, this is encouraging since it suggests that biomechanical changes can be induced rapidly and effectively, even for the elderly subjects.

Two of the subjects, one 30 year old and one 65 year old, were able to stand up from the chair using only 15N of force, above their seated body weight. This was outstanding in comparison to most other performances, with force ratios to body weight of about 0.03 compared to the normal of 0.14. The raw data are included in Appendix 1 for comparison of individual differences. Observing these performances, the movements were incredibly slow and controlled and demonstrated the degree to which force production can be altered by some subjects. Such remarkable improvements in force reduction call into question the need for expensive "ergonomically" designed chairs until other simpler, less expensive means for improving egress have been tried.

### **Concluding Remarks**

The value of the existing study, is primarily that it compares the responses of older subjects to video and verbal versus non-verbal instructions, and, mental practice to physical practice, to those of younger subjects. Since most of other studies in these areas have used a college aged population, theories and predictions have been developed to describe how these subjects behave. This has not been the case for elderly subjects. For the video and verbal versus non-verbal instructions the older subjects were found to respond the same to the one time teaching intervention. However, for the mental/physical practice, the older subjects responded with more ease to the physical practice but were responsive and only slightly less efficient in responding to the mental practice.



The chair that had been constructed to fit on the force plate cannot be said to be 'normal'. Therefore, in terms of forces produced to rise from the chair, it cannot be said that they were in a totally "normal" range. The chair did, however, provide a standard starting position in the seated position and also, afforded the necessary ability to change height for subjects (by the use of wooden blocks). A future study might consider using a large sized force platform, or better still, 2 force platforms one for sitting on and the other to place the feet on and stand up unto. Furthermore, a faster software system would have facilitated more testing.

To further this study it might also be interesting to test the subjects over 2-3 days to see if one group retained more of the newly-learned pattern than the other or if there were any dormant responses that might have been triggered after more practice sessions. For the purpose of the study presented here, the time limit was 20-30 minutes which is probably the maximum attention span that one could expect a subject to have for this type of performance. Another way to further the study could have been to use a third group of subjects in the second experiment. They would be given then 8 consecutive mental practices (with no knowledge of results) followed by 2 physical practices with knowledge of results. This would allow the subjects to work on just the feeling of the movement without any physical practice, which was a distraction of 3.5 minutes, and might have weakened the subjects feeling of improvement. As instructions to minimize the rate of vertical acceleration are theoretically the way to reduce peak Z force, the addition of cinematography data to measure movement time, would have been a useful adjunct to prove this point.

To extend the study into one that could be used for teaching the sit-to-stand movement, the facilities that were used would need to be expanded. The requirements would definitely include a 'normal' chair as this is what the subject would wish to accomplish egress from. Secondly, a larger force plate would be more suitable. If the subjects were allowed to use their arms (sensors could be used on the chair arms to monitor force) there would be more flexible movement opportunities given to the subject. While numerous questions arise from the results presented here, the study has shown a potential for changing clinically-relevant movement patterns based on the established principles of motor learning. Further, it supports the intentions of Warner & McNeill (1988), that greater study of the possible applications of perceptual-motor behaviour principles in the clinical setting is warranted.

## **SUMMARY OF CONCLUSIONS**

1. The observational learners did not reduce their peak Z forces any differently than the non-verbal group.

2. In both experiments 1 and 2, all subjects managed to significantly decrease peak Z forces with practice trials.

3. The 50% Mental Practice and 50% Physical Practice group were found to be just as efficient in changing their force patterns as the 100% Physical Practice group.

4. The older adults using Mental practice were not found to lower the forces as much as the older adults physically practicing.

5. Younger adults lowered their peak Z forces more successfully using Mental Practice than Physical Practice.

Conclusions 4 and 5 have been interpolated from Figure 2.

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**APPENDIX A  
RAW DATA SCORES**

Subject	Instructions	Age Group	Age	Sitting Force	Total 1	Total 2	Total 3	Total 4	Total 5	Total 6	Total 7	Total 8
1	NY	O	87	679.6	800	853	738	745	752	755	731	714
2	NY	O	78	701.1	788	780	751	740	771	744	771	775
3	NY	O	88	880.2	774	818	818	782	788	775	772	782
4	NY	O	85	830.5	721	718	689	678	694	705	692	679
5	NY	O	78	710	774	780	787	788	784	782	788	758
6	NY	O	85	582.6	684	683	648	638	641	632	682	618
7	YY	O	88	588.1	859	781	686	637	650	636	655	638
8	YY	O	86	607.2	853	828	781	773	778	772	751	741
9	YY	O	85	665.5	722	732	710	688	700	688	680	685
10	YY	O	86	524.5	623	629	585	588	582	588	582	582
11	YY	O	87	778.4	812	855	871	820	849	830	827	848
12	YY	O	88	559.6	715	735	724	682	703	684	700	685
13	NY	Y		538.4	704	703	613	614	610	620	621	633
14	NY	Y		584.1	742	738	648	635	670	681	654	627
15	NY	Y		848	959	1018	982	925	929	924	947	905
16	NY	Y		857	883	791	799	805	778	762	789	773
17	NY	Y		736	848	892	837	818	842	854	887	815
18	NY	Y		781.2	848	839	784	788	758	741	714	782
19	YY	Y		678.3	802	795	742	728	740	737	728	731
20	YY	Y		571.8	677	680	603	645	653	638	645	641
21	YY	Y		604.7	784	785	788	675	708	675	725	688
22	YY	Y		631.4	658	778	776	731	745	754	713	715
23	YY	Y		678.4	888	982	884	848	818	887	771	818
24	YY	Y		582.3	680	853	833	835	824	818	825	818

Subject	Practice	Group	Age	SH Force	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10
1	PP	0	77	552	659	649	637	634	608	603	600	597	596	591
2	PP	0	80	625	703	730	680	670	683	726	674	658	694	679
3	PP	0	73	808	910	940	881	859	865	848	848	832	855	857
4	PP	0	76	620	733	724	714	679	672	690	653	669	638	642
5	PP	0	67	844	968	987	987	944	969	894	927	930	927	913
6	PP	0	74	742	830	900	872	849	826	794	820	785	781	777
7	PP	0	76	447	571	561	506	502	512	519	497	512	500	495
8	PP	0	74	669	762	753	722	740	771	766	707	754	743	726
9	PP	0	70	751	873	845	805	829	808	817	806	790	789	784
10	PP	0	69	607	746	722	704	693	717	754	698	716	720	730
11	PP	0	65	695	840	831	759	762	746	787	741	760	781	757
12	PP	0	70	655	825	757	730	711	725	731	716	712	733	716
13	PP	Y		648	801	745	700	684	703	692	693	690	694	694
14	PP	Y		663	828	834	776	742	770	783	767	757	773	776
15	PP	Y		709	884	886	823	824	827	842	810	789	819	815
16	PP	Y		540	673	648	600	606	616	590	596	579	577	580
17	PP	Y		611	757	755	742	703	728	713	711	694	680	671
18	PP	Y		511	763	696	647	576	624	596	601	556	585	587
19	PP	Y		644	779	809	735	706	730	704	719	712	722	716
20	PP	Y		723	693	909	807	810	788	788	769	757	756	757
21	PP	Y		644	771	757	732	703	740	705	708	709	711	686
22	PP	Y		584	715	699	653	630	643	641	630	638	632	628
23	PP	Y		483	586	621	497	499	504	502	525	499	506	503
24	PP	Y		630	785	774	713	707	712	709	729	707	695	704

**APPENDIX B**  
**INFORMATION AND CONSENT FORMS**

**STUDY :** The Effects of Instruction and Practice on the Sit-to-stand movement

**PURPOSE :** To help decide why some older subjects have difficulty with the sit-to-stand movement and which type of instruction and practice is of most use in correctional teaching.

**SUBJECTS :** For the two experiments, one for instruction and one for practice, a total of 48 females will be tested. The 24 younger subjects will be in the age range 18-30 years and the 24 older subjects will be in the age range 65-80 years. All subjects should be pretty fit and be able to stand up 16-18 times in a row, without using their hands. Subjects should not have any neurological, orthopaedic, cardiological or respiratory condition that would interfere with the ability to perform the movement pattern.

**METHODS:** Subjects receive instructions from a video recorder or a printed sheet. They are seated on a small wooden bench on a force platform (this is a flat force detector built into the floor, it will record all forces applied to the bench or floor while standing up). The subject stands up in their normal pattern once they are told/ready, after each trial the subject is told a number relating to their performance, there will be about 12 attempts at standing up.

**TIME REQUIREMENTS:** One attendance lasting about 30 minutes at the St Denis centre on College Ave.

**RESEARCHER:** Marianne Attridge  
For more information contact:  
Mornings- Physiotherapy WWHC 977-8119  
Afternoons and Evenings 258-1332  
Transport willingly provided.

CONSENT FORM

I, \_\_\_\_\_

- Have willingly volunteered to be in this experiment which studies the ability to stand from a sitting position.
- know that the experiment will cause me no physical harm.
- have had the experimental regime explained to me.
- know that I may leave at any time.
- know that my identity and my results will remain in confidence and will not be disclosed.

Signed \_\_\_\_\_

Witness \_\_\_\_\_

**VITA AUCTORIS**

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